N°. 146

PRINCIPLES
OF
THE HUMAN MIND

DEDUCED FROM PHYSICAL LAWS

BEING A SEQUEL TO

ELEMENTS OF ELECTRO-BIOLOGY;

TOGETHER WITH THE LECTURE

On the Voltaic Mechanism of Man,

DELIVERED AT THE LONDON INSTITUTION

APRIL 11, 1849.

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LONDON:
LONGMAN, BROWN, GREEN & LONGMANS,
PATERNOSTER ROW,
AND
HORNE, THORNTHWAITE & WOOD,
123, NEWGATE STREET.

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PRINCIPLES OF THE HUMAN MIND.

KNOWLEDGE OF THE EXTERNAL WORLD.

1. Our ideas of the external world arise, primarily, from an action upon the ultimate nervous fibres of the organs of sensation, by the specific stimulus competent to excite each organ of sensation respectively.

2. Each primitive nervous fibril is called a unit; the repetition of units, *Number*.

3. That which is competent to act upon these nervous fibrils is called *Matter*.

4. Whenever matter undergoes any change which renders it appreciable to our senses, it is said to evince *Force*.

5. The definite combination of nervous fibres excited to action, determines the *character of the idea* presented to the mind, such as form, position, magnitude.

6. Each combination may be expressed by a word or cypher, and forms a definite image. The use of words is called *Language*.

7. The sum total of all the possible combinations of the ultimate nervous fibrils, excited to action, comprises all the possible images which can be represented to the mind.

8. Inasmuch as the possible combination of all the nervous fibrils is immensely numerous, so are the

images which may be reflected in the mind immensely numerous.

SENSES.

9. An idea is represented to the mind, when any one or more of the filaments of either specific organ of sensation is excited without reference to the definite image thereby produced.

10 This solitary idea, derived from the filaments of the eye, is termed, *Vision;* of the ear, *Hearing ;* of the nose, *Smelling;* of the palate, *Tasting;* of the skin, *Feeling;* and, probably, from the nerves communicating the changes occurring in our own body, *Personality.*

COMBINATION OF SENSES.

11. The perfect knowledge of any object is obtained by impressions received by the sum of the organs of sensation.

12. But as matter may exist without exciting all the organs of sensation at one time, we determine the combination of senses which has concurred to give us the knowledge of any external object.

INFINITY.

13. An idea is represented from the excitement of one or all the nervous fibrils of any organ of sensation indiscriminately. This idea is infinite, inasmuch as it is indivisible, incapable of addition and represents totality.*

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* Infinity is sometimes confounded with its hyperbolical use in the sense of endless number.

TIME.

14. Our knowledge of the external world at any given period, is the sum-total of the images from all our senses.

15. These images represented to the mind are perpetually changing.

16. When images change, one remains; the other changes perhaps several times before the first changes. The relation of these changes to each other is termed *the time of their occurrence;* that which changes the least frequently is said to be of *the longest duration.*

CAUSE.

17. In the change of images, when one specific image never appears without a similar antecedent, and the matter in the external world which gave rise to the first image set in motion the second—the antecedent image is said *to cause* the second image.

18. The mind finds great difficulty in distinguishing between concomitance and cause, because the matter which produces an antecedent image may not set in motion the matter which produced the second image.

PLEASURE AND PAIN.

19. When images of the external world are produced with a certain intensity—the idea of *Pleasure* is excited — when with a greater intensity, the idea of *Pain.**

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* Every action of our lives is either pleasurable or painful; and thus we perceive how vastly the former state preponderates over the latter

20. The transition from Pleasure to Pain being sudden, not gradual, it follows, that the nature of the action on the brain and, consequently, of the ideas, is different.

MEMORY.

21. An image once formed in the brain produces an indelible impression, and may at any future time recur. This property is called *Memory.*

CONSCIOUSNESS.

22. When an image is produced by an action upon the external senses, the actions on the organs of sense concur with the actions in the brain; and the image is then a *Reality.*

23. When an image occurs to the mind without a corresponding simultaneous action of the body, it is called a *Thought.*

24. The power to distinguish between a thought and a reality, is called *Consciousness.*

INSTINCTIVE IDEAS.

25. Several ideas must necessarily co-exist, giving rise to compound ideas always existing in the brain: thus personality and infinity give us the idea of the Soul; pleasure and infinity, of Good; pain and infinity, of Evil; cause and infinity, of God; time and infinity, of Eternity; infinity, pleasure and time, of Heaven; infinity, pain and time, of Hell.*

As these instinctive ideas are simply thoughts, and cannot be proved by our external senses, the mind may be led at times to deny the reality of their existence. Revelation, however, declares their truth, and thus compensates for the natural weakness of man.

26. These instinctive ideas are not produced by the immediate action of external influences, but have their origin in the construction of the brain, or organ of thought.

27. Instinctive ideas belong to the higher class of mental images; and there is no reason to suppose that a more simple idea is implanted in the human species. In the lower animals, however, it is apparent that either other images exist, which guide the creatures to perform their operations—as the bird to build the nest—the bee, the honey-comb: or that the nervous system is so constructed, that the creature is led to perform specific acts under some definite excitement.

REFLECTION.

28. When images already implanted in the brain, which possess many points in common, continually re-appear, the party is said to be reflecting.

29. During reflection, the influences of the external world to produce new images are entirely, or to a great part, neglected.

30. By reflection, ideas may be combined so as to form general laws.

31. By reflection, general laws may be applied to specific instances, or images may be analysed into their component parts.

JUDGMENT.

32. When an idea is represented to the mind, it either accords or discords with other ideas previously

received, or with general laws resulting therefrom, or with the moral law. The determination between this concordance or discordance is called *Judgment.*

IMAGINATION.

33. Man has the power of uniting two or more antecedent images, or the parts of two or more antecedent images. By this power, a totally new image is formed, and hence it is called *Imagination.*

34. Observation is the basis of fancy; and the novelist is fruitful only in proportion as he stores his mind with natural images.

ACTION.

35. Man acts by electricity, which is set in motion through the muscular structures, whereby contraction ensues, and parts of the body are moved

36. Action may be produced by the immediate influence of the external agents upon the body, which give rise to a new image in the brain; and action may also be produced by the recurrence of a former image.

SPECIFIC ACTION.

37. The mind is one and indivisible; and thus, the particular muscular movement which the electrical force determines, is not only regulated by an immediate image, but by every other image which has at any former time been implanted in the brain.

38. Pleasure and pain regulate all actions; hence the particular movement which is determined, arises from the pleasurable or painful character of all former images; as animals, as well as human beings, seek those actions which are likely to be pleasurable, and eschew those which are likely to be painful.

39. But the action determined in any particular instance may be painful for the sake of obtaining greater pleasure at future periods; and the idea of obtaining infinite pleasure may allow of the most intense immediate pain.

HOPE AND FEAR.

40. The idea of future pleasure is called Hope—of future pain, Fear. The government of mankind is conducted by exciting Hope and Fear.

DESIRE.

41. When a tendency to act exists, it is called *Desire;* and always exists, more or less, when a being is in good health, and in a state free from fatigue.

VIRTUE AND VICE.

42. All actions in the higher generalisations, would give the idea either of infinite pleasure or of infinite pain. Actions which concur with those which lead to infinite pleasure, are called Virtuous; and those which lead to infinite pain, are called Vicious.

MORAL LAW.

43. The moral law, being infinite, is competent to control all actions. It is therefore important that it should be frequently and strongly impressed upon the human mind.

VOLITION.

44. The resultant of the force of an immediate stimulus and of all former ideas implanted in the brain, is termed *Volition*.

FREE AGENCY.

45. A man is born a free agent; but after images are once implanted, he is compelled to act from the ideas existing in his brain. Hence, could we but tell the exact ideas which any human being possessed, it would be practicable to foretell his line of action under any defined circumstance.

CERTAIN SPECIFIC IDEAS.

LIFE.

46. The term Life is assigned to the idea which the mind forms of the capacity of an organised being to perform its functions.

DEATH.

47. The term Death is assigned to the idea which

the mind receives of an organised being, incompetent to perform the vital actions.

MIND.

48. The term Mind is assigned to the general idea of any action of the brain, which is a part of the organisation of man. An idea is the term assigned to any specific action in the brain.

ORGANISATION.

49. Organisation is the term assigned to the construction of a being to adapt it to perform certain functions.

FUTURE STATE.

50. The mind has constantly represented to it the idea of a personality which will exist infinitely.

51. Whilst, however, the idea exists, we have no power to learn the properties of infinity; and hence we cannot define the nature of the state in which we shall live hereafter.

DISEASED STATES OF MIND.

INSANE IDEAS.

52. Whenever an idea appears in the brain, which is neither instinctive nor is due to external causes, nor is deduced by the ordinary operation of the brain, it is said to be an *Insane Idea*.

53. When this idea is continuously the same, the party is said to have a *Monomania*.

54. When various images appear and vanish indiscriminately, the state is called *Incoherence;* and when this state is combined with more or less unconsciousness, it is termed *Delirium*.

55. The danger of insane ideas depends upon the *distinctness* with which the idea is impressed upon the brain; for it will determine the party to act in proportion to the power with which it is impressed.

56. To the violent actions arising from strongly implanted diseased ideas, the term MANIA is given; and the violence of the Mania is proportionate to the power of the delusion. To the individual it is an exaltation of pleasure.

57. When, from the delusion, the patient is in continual fear, he is said to be *melancholy;* and it is probably, to the individual, an exaltation of pain.

58. When a fixed insane idea exists in the mind, the party cannot be said to be partially deluded; for, inasmuch as the mind is one and indivisible, it will control all actions.*

59. A strong moral impression may counteract an insane image, as a party may be kept from doing wrong, by feeling assured that it will lead to present or future inconvenience to himself.

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* As a matter of jurisprudence, it has been held by the Lord Chancellors, in the House of Lords, that the mind cannot be said to to be partially deluded, inasmuch as it is one and indivisible.

DEFECTIVE STATE OF MIND.

IDIOTCY.

60. When the structure of the brain is congenitally defective, so that it cannot perform all its normal actions, the party is said to be an idiot.

LOSS OF MEMORY.

61. Sometimes the power of memory is intermittent, or is totally lost, as after the frequent recurrence of epileptic fits.

FITS

62. Any interval of unconsciousness, except sleep, is called a Fit.

FATUITY.

63. When, from loss of memory, or want of power in the brain, the functions of reflection or judgment are not perfectly performed, the individual is said to be *fatuous*.

LOSS OF SENSATION.

64. Sometimes the power of receiving impressions from the external world is diminished or lost, as in blindness, deafness, etc.

PARALYSIS.

65. When parts of the body do not move by volition, they are said to be paralysed.

SENILE IMBECILITY.

66. In old age, the brain loses its power to receive new images, to restore by-gone impressions, to connect different images, or to apply general laws to specific instances. That which ennobles the man has passed away; the outward form remains, but the inward structure has lost its power to act. Childhood again ensues—not to acquire new ideas, but to forget those before implanted. All that is beautiful or desirable in this world has passed away—the brain has lost its power—the mind ceases—the very existence of the man is unknown to himself, till death gives rise to a new life, and discloses that new and glorious state in which our organisation teaches us that man will be immaterial and immortal.

VARIETIES OF RACES.

67. As individuals differ in their organisation, it follows that they differ in their capacity to perform various acts, and we may presume that the mind being one of the functions of the body, is of varying power in different individuals.

68. The observations which apply to different individuals, apply with greater force to different races.

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PREFACE.

Some years since, M. Roret, the distinguished French publisher, did me the honour of causing to be made a translation into the French language, of my "Elements of Electro-Metallurgy" in which it met with as signal a success as the original edition in this country.

As soon as M. Roret received my work on Electro-Biology, he also caused it to be immediately translated, and kindly wrote to me to know whether I desired to make any additions to the English text.

After a careful consideration, I determined to write a short Epitome of the Principles of the Human Mind, deduced from Electro-Biology, to form an Appendix to that work.

But, after the remarkable kindness with which the work has been received in this country by my friends and the public, I feel that it would be a want of courtesy, if not an act of ingratitude, to allow farther remarks upon the same subject, however unimportant they may be, to appear in a foreign country before they were issued in the English language.

I apprehend that the time is fast approaching, when no other system of mental science will be acknowledged but that which is based upon physical laws and the structure of the brain; and if my researches shall be found hereafter to have contributed to the development of true Philosophy, I shall indeed feel more than amply rewarded for the hours of anxious but delightful labour spent in its development.

7, FINSBURY CIRCUS.
Sept. 18*th*. 1849.

LECTURE

ON

ELECTRO-BIOLOGY,

OR

THE VOLTAIC MECHANISM OF MAN;

DELIVERED AT THE LONDON INSTITUTION.

Reprinted from "the Lancet," April, 21st, 1849.

ELECTRO-BIOLOGY;

OR,

THE VOLTAIC MECHANISM OF MAN.

THE subject of my present lecture is Electro-Biology, which literally means, neither more nor less than the relation of electricity to the vital functions. Now, systematic writers divide the vital functions into two great classes—into those of animal life, and into those of organic life.

The functions of animal life will particularly occupy our attention this evening; and for their consideration, we shall have to study the apparatus by which the animal receives impressions from the external world, transmits them to the brain, registers them, combines them, and acts, not only upon the immediate impressions, but also upon those which it has received at former periods.

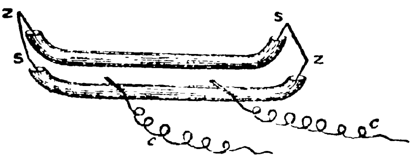
For the manifestation of the functions of animal life, we require a central parenchyma or brain, a peripheral or body, the two being connected together by a peculiar tissue called "nerve-fibre;" and at both situations a proper supply of bright arterial blood is requisite, for the production of the phenomena of life. If we look to purely physical contrivances, we find that similar conditions are fulfilled by a double voltaic circuit.

Z ———————— S
S ———————— Z

If we abstract the proper exciting fluid from either end, or substitute any other fluid, or destroy the structure at one end or the other, or divide the connecting portions or wires, the effects proper to the apparatus will not be manifested, and the battery will be destroyed. The analogy between the mechanism of a double voltaic circuit and that of animal life is quite complete; for if we pith an animal, an operation which separates the brain from the body, or remove the blood from the brain, or from the peripheral part, or destroy the structure of either the brain or the periphery, action is stopped, and animal life ceases.

You will at once say, doubtless, that man has no metallic wires, no plates; and therefore, you may naturally ask, how far does that fact destroys the analogy which I have given to you. It is not necessary, however, that the connecting portion should consist of metal, and though all present are doubtless accustomed to see the electric telegraphic wires along the course of the railways, yet I have here upon the table an example of fluid telegraphic conductors, which answer as efficiently for the conducting of the voltaic force, as wires or metals. Those amongst you who reside at Upper Clapton, may remember some time since to have seen mysterious wires placed at an elevated situation round the Horse-shoe Point on the River Lea. At the time these wires were in that situation, I was experimenting upon the conducting power of liquids, and they were found to possess that property in an extraordinary degree. If the nerves, however, carry the voltaic force, they might perhaps be expected to have within themselves some means of insulation; and from my own microscopical examination of nerve-fibre perfectly fresh, I believe that a layer of fat exists in the interio of each primitive fibril, which would as efficiently insulate it as the gutta percha of my tube does these artificial nerves which are placed on the table.

FIG. 1.*



In this double voltaic appa ratus before you, in whic the communicating portio consists of gutta-percha tub ing, filled with acid and water a powerful voltaic current passing, but one which will yield no indications of its presenc to ordinary voltaic tests. It is no easy matter, gentlemen,

Double voltaic circuit, with gutta-percha tubes; Z, zinc; S, silver; C, C, copp wires for electro-voltaic test.

prove the presence of a voltaic current in a fluid, and for a long period I did not know how to proceed to render its existence certain. However, at last I observed if any metal capable of being oxidized was interposed in the path of a voltaic circuit, that one portion becomes positive, the other negative, and that this result is no fanciful chimera, I now show you an electro-metallurgic precipitating trough, in which a piece of copper is inserted between the positive and negative plates, and you will at once perceive that the portion near the negative pole has become acted upon or positive, the part nearest the positive pole has become negative, and has metallic copper deposited upon it. From this experiment I saw that a mode was afforded to me of ascertaining the presence of a voltaic circuit in any fluid. To give you a practical illustration of the value of the electro-voltaic test, I have introduced two copper wires (fig. 1, C C) into one of the gutta-percha tubes constituting my artificial nerves, and you will perceive that the moment I connect them with a galvanometer, deflection ensues. Animal bodies consist solely of membranes and fluids, and therefore, in the order of my investigations, I had to study batteries solely composed of similar materials. This form of voltaic circuit is extremely difficult to investigate, though one is placed upon the table for your inspection.

After I had thoroughly studied the electro-voltaic test, the time arrived to ascertain whether a voltaic current was actually passing during nervous action. For although the analogies which I have detailed were, to my mind, complete, yet analogy would be useless without the corroboration of direct experiment. My first experiment was, to introduce two steel needles into a rabbit; the first into the masseter, or muscle which enables the creature to masticate; the second, into the subcutaneous cellular tissue. After two or three minutes, the creature, which was very tame, attempted to bite my finger; the power of volition was sent to the muscle; this acted upon my electro-voltaic test, and you may judge of my inexpressible delight, when the deflection of the needle showed to my mind the mechanism of volition. These needles being between the skin and muscle, the course of the voltaic circuit is clearly demonstrated to exist between these two points, and therefore each required a most minute consideration.

Sensations are received by various organs which are destined to be acted upon by certain physical forces, as the eye by light, the ear by sound, the nose by odours, the tongue by savours, or the skin by heat or force.

It is quite certain that if a voltaic circuit is generated in the eye, there must be such contrivances as photo-voltaic circuits, that is, voltaic circuits in which light causes the evolution of electricity. In trying the experiment, I found that there were not only an extensive series of combinations in which the sun's rays determine the generation of electricity, but that in one division light caused a positive voltaic circuit; in the second, a negative voltaic circuit. The table of these circuits will illustrate the manner in which these circuits are formed, by using solutions so arranged that one portion may be screened from the light, and the second may be acted upon powerfully by the sun's rays.

NEGATIVE PHOTO-VOLTAIC CIRCUITS.

Mixed solutions of proto-sulphate of iron and nitrate of silver.
,, ,, gallic acid and nitrate of silver.
,, ,, oxalic acid and chloride of gold.
,, ,, ferrocyanate of potash and ammonio-per-citrate of iron.
,, ,, ferrocyanate of potash and ammonio-per-tartrate of iron.
,, ,, ferrocyanate of potash and potassio-tartrate of iron.

POSITIVE PHOTO-VOLTAIC CIRCUITS.

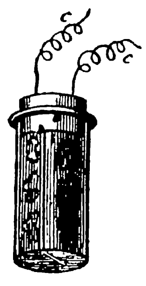
Mixed solutions of per-nitrate of iron and red ferrocyanate of potash.
,, ,, bromine water, phosphorus water, and per-nitrate of iron.

These experiments I cannot show you this evening, because I cannot command the sun's rays to shine upon one side of my apparatus; but from what I have stated, you will perceive that it is quite within the range of ordinary physical effects to have voltaic circuits set in action by light.

Having developed photo-voltaic circuits, the eye itself next demands our attention; and we find nerve and blood to be abundantly supplied to that organ. The electro-voltaic test is best applied by the insertion of one needle into the choroid, the second into the muscles of the eyeball, and I found a slight deflection of the galvanometer when a strong light was thrown into the eye, proving that vision was a voltaic phenomenon.

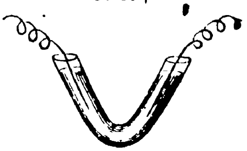
The essential part of the organ of hearing is encased in textures of such extreme hardness, that it will probably be for ever prevented from being the subject of direct experiment. In the cochlea, I believe we may reasonably assume that the pitch of the note is determined; and in the semicircular canals which are placed in the three orthogonal planes of a cube, physiologists are pretty generally agreed that animals learn the direction of sound. Blood and nerve—essentials to voltaic action—are here distributed, and no physical difficulty is presented to the probability of a voltaic circuit being determined by sounds.

FIG. 2.*



The nasal organ is, like the ear and eye, liberally supplied with blood and nerve-fibres. The voltaic circuit is easily demonstrated by the electro-voltaic test; but the animal has an extraordinary repugnance to the operation, and you must be extremely careful not to be deceived by other secretions which are competent to set up the voltaic action. I can very readily show you that it is not at all difficult to form voltaic circuits, in which odours should excite the electric action. The tube which I hold in my hand contains two iron plates, which are separated by a membrane, and on each side pieces of sponge, dipped in very dilute muriatic acid, are arranged. Now, if ammoniacal vapour, which produces the most powerful action on the natural nose, be brought under one side of the diaphragm, you perceive that a very strong action of the needle is immediately produced. The experiment which I have selected is one which shows the result easily, rapidly, and in a very marked manner; but I should not think it a bold assertion to declare, that with a little trouble and patience I could exhibit voltaic effects, although perhaps to a less marked extent, with every other odoriferous body.

FIG. 3.†

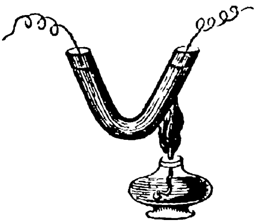


When an animal tastes, the matter which contains the savour comes in immediate contact with the tongue, and is there probably absorbed. I need hardly state, that the essentials for sensation, blood and nerve, are abundantly supplied to that organ. With respect to physical contrivances analogical with the tongue, it is very easy to show voltaic force excited by savours; and I have here a V-shaped tube, containing a solution of pernitrate of iron, and two platinum poles, which exhibit by themselves no signs of electric action. As soon, however, as I drop a little infusion of meat into one side of the tube, you will instantly perceive that the galvanometer shows signs of action. There is no mystery about the meat, as sugar, or, in fact, any other savour, would have had a similar property in a greater or less degree. The direct examination of the tongue in the living animal affords unsatisfactory results, inasmuch as secretions in the mouth are very apt to give wrong results—a circumstance which should be very carefully guarded against.

* Apparatus showing the generation of a voltaic circuit by odours.

† Apparatus showing the generation of a voltaic circuit by savours.

FIG. 4.*



The last organ of sensation to which I have to beg your attention is the skin. Now, by the ordinary sensor nerves, we derive two sets of impressions of somewhat different characters—for instance, we are enabled to judge of impressions upon the body by either heat or force, or what may be termed cænaisthenics. We are also enabled to judge of the changes taking place within our own body, which estimation may be more properly called somaisthenics By somaisthenics we are enabled to estimate the slightest muscular motion, and, in fact, I cannot move my finger or my arm to even the slightest extent without having a perfectly distinct idea of the amount of motion produced.

The skin is acted upon by variations of temperature and force; hence we have to inquire how far heat and force can be employed to set in motion the voltaic force. In experimenting upon the variations of temperature, I found a large series of thermo-voltaic circuits, which curiously enough, are analogical to photo-voltaic circuits, inasmuch as heat, at various times, determines both negative and positive circuits in the same manner as light. I have here a negative thermo-voltaic circuit. The apparatus, as you perceive, consists of a V-tube, containing sulphate of copper (fig. 4). Into each side of the tube a copper wire is placed, and you perceive, that the moment I apply the heat of a spirit-lamp to one side, the galvanometer is very strongly deflected, the heated side becoming the negative pole.

When force acts upon the skin, I presume the blood corpuscle is prevented from coming in contact with the termination of the nerve-fibre; and I will beg you to bear this supposition in mind, as in a later part of this lecture I shall demonstrate to you, that if this supposition be correct, a voltaic circuit must be generated. My observations upon heat and force simply indicate that a thermo- or dynamo-voltaic circuit is an ordinary voltaic or physical phenomenon; but that by no means proves that in the living body the mechanism of feeling is voltaic. This, however, is an experiment easily shown, for we have but to introduce our electro-voltaic test into the cutaneous textures, when a powerful deflection of the galvanometer occurs whenever we pinch or otherwise irritate the skin. We thus find that the mechanism of all the sensations is voltaic, and according

* Thermo-voltaic circuit in which the voltaic force is produced by heat.

to the laws of the voltaic test, the needle nearest the negative pole becomes positive; that nearest the positive pole, negative. From direct experiment, I should therefore infer, that the organs of sensation all constitute the positive pole of the peripheral battery. These inferences, however, must always be taken with a proper allowance for the complex character of the voltaic circuits in the body, or rather, I would say, for the complex materials of which the circuit is composed.

Sensations are received by a certain definite number of sensor nerves, which constitute the only means we possess of obtaining a knowledge of the external world. The sensor nerves pass to the brain, and then come in contact with a highly vascular tissue, called the grey matter of the brain; and I invite your attention to the very exquisite injections which I have made of that tissue, by means of the solution of carmine, and which will be exhibited under the microscope in the library after the lecture.

Inasmuch as the sensor nerves come in contact with blood-vessels; it follows from voltaic laws, that a voltaic battery exists in the brain, which is opposed to that in the body, and by which the electro-biological circuit is completed. At this point we leave the regions of direct experiment, and we must deduce the mechanism of the central battery according to voltaic laws on the one hand, and the properties of the mind on the other.

I infer that the sensations are simply repeated in the brain, nerve for nerve, action for action, and this first battery I term the sensation or aisthenic battery; the second pole of this battery is probably connected with the corresponding fibre of the opposite side, by what anatomists call a commissure, and which I have illustrated on the table by a voltaic arrangement.

We have represented to our minds, not only simple sensasations, but also combined impressions; thus, whilst I am looking at all the parts of this theatre, one impression—namely, that of a theatre, is brought before my mind. There is no difficulty in obtaining this result by voltaic means; and the mechanism by which I believe it to be accomplished I have termed the syndramic or combination battery. Thus, if we have three primitive nervous fibrils, *A*, *B*, *C*, they may be thus combined, *A B*, *A C*, *B C*, *A B C*. The diagram behind me illustrates this mode of combination; and here, upon the table, I have the voltaic arrangement itself, and you cannot fail to observe that these wires, even on this very limited scale, begin to look like the interlacing which we observe in the brain.

If we divide any space into a certain number of squares, and give to each square a certain name or figure, it will be apparent, that by simply giving the names of the squares filled up with black, the word, or name, or symbol, would at once be accurately described. I have divided this piece of card into certain squares, and if I read you a certain combination of numbers, it would appear, at first, to give no definite idea, but if you examine carefully, you will find that this combination of numbers brings out the word LIFE. This word, I find has been very unfortunately chosen, but in reality I only selected the word in illustration of the principle of combination, because it only consisted of four letters, and because each letter was so formed that it very perfectly filled up square spaces.

Ladies constantly in practice take advantage of this principle in their patterns of worsted work; and it would be possible so to describe a picture, up to the very limit of our powers of sensation, that it might, from the description alone, be repeated in any country, and yet be a perfect fac-simile.

I dwell thus long upon the syndramic, or combination battery, because, in all probability, it constitutes a very large part of the brain. When we consider the large number of ultimate fibres in each organ of sensation, I do not think that we have reason to suppose every possible combination ensues; and even with regard to ordinary sentient nerves, I think that such a universal combination would be embarrassing to the mind, and that the combination probably would only extend to the nerves of each separate region of the body. It is quite certain that we always know the specific sense by which impressions are learnt—that is to say, that we know whether an idea has been derived from the eye, nose, mouth, or other organ of sensation. This resolves itself into one idea for a vast number of sensations, and is a state which can very easily be imitated by voltaic contrivances. I have upon the table a voltaic arrangement of this character, in which but one action is produced from one or all the combinations which exist in the syndramic battery. In some cases, ideas do not arise alone from action on one sense, but on two or more senses at one time—a combination which I infer to occur in the syndramic noemic battery; and lastly, it is necessary to assume, that all these last combinations of each specific sense are connected together into one total in the pneuma-noemic battery, from the opposed pole of which the dynamic or motor nerves spring.

The situation of this important battery is somewhere in the base of the brain; and I believe that in applying the electro-voltaic test in this situation, I have obtained deflection of the galvanometer. Let me, however, speak with the utmost caution upon this point; for although I have tried the experiment over and over again, the animal is almost invariably destroyed, and in fact by the electro-biological maps* which are suspended upon the wall, you will at once perceive that an action here influences every nerve in the body, and thus may very readily destroy vitality.

Now, what are the qualities of this last battery, which has but one impression for all the sensations of the body? We find that it represents totality, and cannot be limited. It has therefore the properties of infinity, and gives to man his most exalted ideas. The ideas of soul, God, eternity, immortality, are obtainable from this battery, acting in conjunction with the lower batteries which I have already described. I regret exceedingly that the hour allotted for this lecture has now been so far spent, that I am unable fully to consider the properties of the mind deducible from the theoretical structure which I have developed upon voltaic laws; but under the circumstances, I feel bound to pass on to matters which can be elucidated by direct experiment.

When the voltaic force is carried by the sensor nerves to the brain, it there causes some change of matter, by which polarity is ever after determined. This phenomena is a physical result of the most ordinary kind; for I have here a solution of argento-cyanide of potassium, with two copper poles, and before the lecture, I passed a voltaic circuit from one pole to the second, by which I have effected a change of matter, and silver has been precipitated on one side. You will now see that immediately I connect the two poles with the galvanometer, a strong deflection will ensue, and to use a metaphorical phrase, the solution has remembered what I did to it. This experiment, which is but a sample of a class, must only be regarded as analogical, and is only valuable to show that voltaic electricity may produce effects which will ever after be apparent.

In the arrangement of the nerves of the body, every sensor nerve is opposed to every motor nerve, and may excite it to action under certain circumstances. Now before I consider this subject in detail, I may state that the voltaic circuit, when it has the choice of two or more roads, invariably takes the easiest route, to the exclusion of all the rest. Here is an arrangement, in which one of my platinized silver batteries is connected with two precipitating troughs, having the same distance to travel in both cases, but one is charged with sulphate of copper, the other with sulphate of zinc; and yet with this trifling difference the entire current has passed through the sulphate of copper, to the exclusion of the sulphate of zinc, because copper was more easily reducible than zinc, and therefore offered a somewhat easier passage to the voltaic force.

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* Copies of the maps in Mr. Smee's "Elements of Electro-Biology.

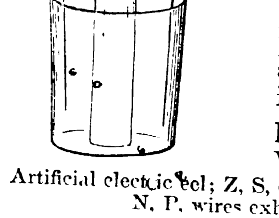
Upon examining the arrangement, I find that the experiment has been tried under the most trying circumstances, as I observe that the positive pole, in the sulphate of copper, is almost entirely dissolved. Notwithstanding, however, this, the law which I have developed and described in my Electro-Metallurgy, still holds good, though I must confess that I should not have risked the demonstration of this extreme application of the law, which fortunately, by accident, has brought the matter more strikingly under your notice.

From this law, we learn that the voltaic circuit would be completed, through the nearest motor nerve, when any sensation was excited, unless obstacles were presented to its passage in that direction, or any circumstances favourable to its passage through any other motor nerve were afforded in some more distant part of the Electro-Biological circuit, when even the furthest motor nerve might be excited to action.

The action of every animal is determined, then, not only by the impression received at the moment, but by every other event which it has registered or remembered from the first moment of its life.

The motor nerves, by which the circuit is completed in the body, are distributed, in man, to the muscles; in other creatures to the electric organs; in others, to light-generating structures. The electric battery of fishes, as it is technically called, is composed of an enormous number of minute cells, supplied with blood vessels. The nervous force, which I have already shown to be voltaic, acts at right angles to the direction of the cells, and there produces some change of matter which instantly causes a powerful voltaic current.

FIG. 5. *



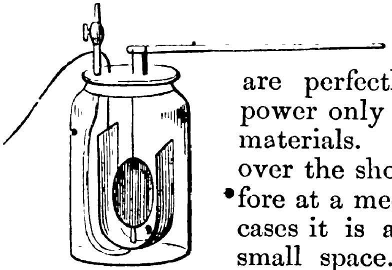
Artificial electric eel; Z, S, connexions to be attached to the battery; N, P, wires exhibiting the phenomena.

I have here a glass vessel, containing a solution of ferrocyanate of potash, into the interior of which is placed a porous cell, containing a a similar solution; a platinum pole is inserted into both vessels, for the purpose of connexion with the galvanometer. Now, if I pass a voltaic current from the outside to the inside, (Z S), no change of matter takes place in one part, the prussiate of potash remains the same; in the other it is converted into the red prussiate. From this change one side becomes strongly positive to the other, and you perceive that so powerful a current has been generated, that the needle completely swings round the instant connexion is made with the galvanometer. I have only shown this experiment upon one cell; but it must be manifest to you, that as every cell adds a certain amount of force, it simply requires a number to make a battery as powerful as that of an electric eel. The artificial electrical eel I have myself constructed, in a vast variety of ways, which I have not now time to consider.

The muscular substance is ultimately divisible into primitive fibrils, which consist of a sheath, called the sarcolemma, containing, in the interior, a peculiar matter, which, during the act of contraction, becomes wider and shorter; and this contraction is caused by a change of matter, produced by the voltaic force, carried through the motor nerves.

I have here a strong piece of gut to imitate the sarcolemma, and into the interior of this I have placed fluid and pieces of platinised silver. Upon the outer side of this gut is placed a strong piece of amalgamated zinc, so that the moment connexion is made, between the zinc and silver, gas is evolved, which renders the bladder wider and shorter, and thus moves this bar of wood over a space of three or four feet (see fig. 6).

Fig. 6. *



The conditions of the natural muscle and artificial muscle are perfectly analogical. Both possess a power only limited by the strength of the materials. In both cases, the power acts over the short end of the lever, and therefore at a mechanical disadvantage. In both cases it is a great power moving over a small space. I, however, can move my natural muscles much quicker than I can my artificial muscle; but you must please to remember that my organs are not competent to construct a machine having such fine tubes as we find in the ultimate muscular fibrils; and for want of this delicacy of construction we sacrifice the speed and rapidityof action observable in the perfection of Nature's operations.

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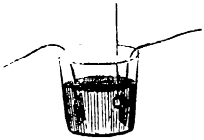
* Artificial muscular substance.

Anxious to lay before you the leading experiments and deductions of this truly delightful subject, I have delivered this lecture with the utmost possible rapidity, and yet I see around me multitudes of experiments which I fear that I shall have no time to explain, as the hour has already passed. By your applause, I understand that you wish me to proceed; but as some of my audience live at considerable distances, I will only detain you by calling your attention very briefly to a few other points. In the first place, we find that man consists of a double voltaic circuit, and therefore we ought to consider the nature of the changes taking place in that voltaic circuit. Now, there are strong reasons to suppose that hydrogen and carbon act as the positive pole, and become changed in that capacity into water and carbonic acid. It would only require one thirty-second the quantity of these materials to produce any result that it would of zinc; and I can assure you, that many a time have I sought diligently and carefully for a voltaic circuit which should be efficiently excited by carbon or coke as a positive element; and I can promise to the fortunate discoverer of such a combination the delight of being able to supersede the steam-engine, and the pleasure of successfully generating the voltaic light. Then, and not till then, will voltaic batteries be employed to the exclusion of every other means of generating force. Although up to the present time I have not been able to use coke or carbon for a positive pole, I have succeeded in making a variety of circuits, in which substances composed of carbon and hydrogen form powerful voltaic circuits; for instance, sugar and nitric acid, oxalic acid and chloride of gold, ferrocyanate of potash and nitric acid, constitute examples of this class of batteries.

The voltaic circuit in animals is exactly balanced, and does not act without some impression to set in motion the electric current. The arterial or oxygenised corpuscles are admirably adapted for this purpose, and I have here an experiment which will illustrate their functions in a very beautiful manner. The glass vessel which I hold in my hand contains a solution of common salt, and two iron poles are inserted into it. Now in this state everything is balanced, and no voltaic force is exhibited. If I take an artificial corpuscle made of animal membrane, containing a little per-nitrate of iron, and bring it in contact with one of the iron poles, a very powerful deflection of the galvanometer ensues, indicating the presence of a current. When, however, one corpuscle is placed against each plate of iron, the effect is again balanced, and no voltaic circuit arises. These experiments well indicate the functions of the blood corpuscle in the living body, for when one is in contact with each end of the nerve fibre, no current can take place, but the moment one is removed, or acted upon by heat, light, or other forces, a strong voltaic battery is formed.

Fig. 7*



I would gladly have occupied your attention with a few remarks upon the relations of electricity to organic or cell-life. By a modification of the aggregation of cells, a plant produces leaves, stalks, flowers, or roots, which every gardener knows is, to a certain extent, as much under human control as digging, raking, or hoeing. During the prevalence of the potato malady, I subjected the plant to every form of electricity, and in every possible manner, over long periods, without obtaining any result.

There is, however, one remarkable circumstance to be noticed with regard to the relation of electricity to cell-life, for I have found that electric currents stop the circulation of the blood, as suddenly as a stop does a watch when put down; and this entire stoppage of the circulation extends not only to the blood corpuscle, but also to the lymph corpuscle which creeps so slowly along the side of the vessel.

If we take a review of the functions of animal life, we find that all sensations, the registration of impressions, thought, action, and other phenomena of animal life, are voltaic effects, and solely obedient to physical laws: and to the idea of the performance of these functions we assign the idea of vitality. Life, therefore, is one word used to signify a number of changes. It is no independent reality apart from the matter which exhibits these phenomena. Neither is it an imponderable attached to matter; nor is it an all-pervading ether, or *anima mundi*, as some philosophers would have us suppose. Life, mind, memory, reason, thought, come from organization, are purely physical phenomena, and cease at death.

Man, however, is immortal. Man, at all times, and in all regions, has believed in his immortality. Now that which is mortal can have no relation with that which gives to man his immortality. That which is infinite must not be limited; time must not be confounded with eternity, matter with space, the body with the soul, nor material actions with God.

Artificial blood corpuscle.

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Electro-biology, then, leads us no less to infer, than religion commands us to believe, "that the dead shall be raised incorruptible, and we shall be changed."

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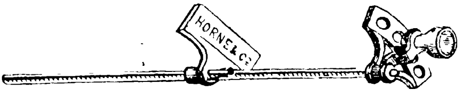

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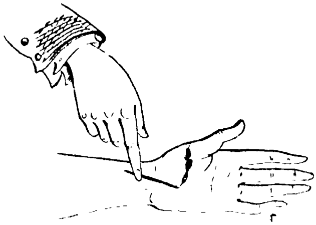
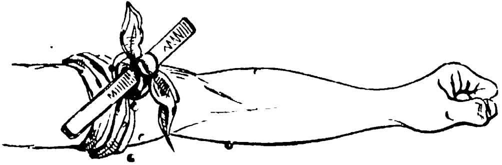


Arterial bleeding is known from the bright scarlet colour of the blood, and from its issuing in jerks. To stop it, put your finger in the wound and press upon the bleeding aperture, and as long as this pressure is properly applied, bleeding cannot occur (Fig. 1). Or, tie a handkerchief twice round the limb, above the injury, and place a piece of stick in it, and turn till the pressure is so great that

ACCIDENTS AND EMERGENCIES.

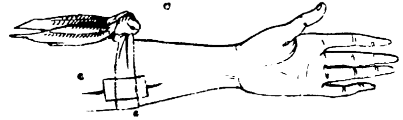
the blood cannot flow (Fig. 2). Or, fold a piece of soft rag several times, and

Fig. 2.



put it quickly over the aperture, and secure it in its proper place by a piece of broad tape, or a bandage (Fig. 3).

Fig. 3.



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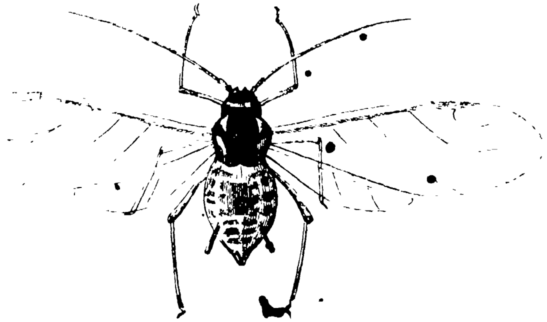

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